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Using Data Envelopment Analysis to Evaluate Technical Training Program for Maintenance Units

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Abstract: Applying data envelope analysis (DEA), this study focuses on the influences of objectivity and subjectivity on aircraft maintenance supervision evaluation and inspection procedure; the aim is to improve overall logistic operation and training efficiency. Moreover, the results of this analysis will be helpful for making decisions in training, management, capability and competitiveness.

Keywords: Data Envelopment Analysis, Performance Assessment, Maintenance Efficiency

1. Introduction

The logistic goal is to ensure flight safety with efficient aircraft accessory repair and maintenance, even under tough circumstances, such as budget cuts, demobilization, technical skills being passed down, organization changes, personnel leaving, recruiting of new employees and low manpower efficiency. To achieve training efficiency, in the face of the negative reasons above, the training control unit needs adequate arrangement and adjustment in its training courses in order to reduce unnecessary work hours.

Among the existing common performance evaluation methods, DEA is the most suitable method to evaluate multiple inputs and outputs (Farrell, 1957; Shephard, 1970). The DEA model was first developed by Charnes, Cooper and Rhodes in 1978; they proposed the CCR model. Following the CCR model, Banker, Charnes & Cooper proposed the BCC model in 1984. Afterwards, there were various modified models proposed by different researchers.

This study basically adopts the DEA systematic application procedure proposed by Golany and Roll (1989) and the DEA performance measurement system diagram suggested by Michael and Barry (1991).

2. Key steps of DEA procedure

2.1 Definition of the selection criteria for the decision-making units (DMU)

DEA is mainly employed to compare with the relative efficiency of each DMU; therefore, the DMU should have comparative meaning, i.e. similar units having different efficiency rates which are measurable. Each DMU must possess the following conditions: (1) The DMU should have the same goal and implement similar work. (2) The DMU should operate under the same marketing conditions. (3) There should be the same input and output items influencing the DMU's performance.

2.2 The choice of units to be evaluated

This research selects twelve factories in charge of aircraft and their accessories maintenance in logistics depots. The period of collecting maintenance data was from July, 2011 to Dec. 2012, i.e. eighteen months in total.

2.3 Selection of inputs and outputs

In selecting input and output items it is necessary to consider at least the organization's tasks and goals, the unit's features, the nature and availability of the data, and the relationship between input and output items. In terms of the systematic concept, organizational activities are meant to transform various resources into output, and the various resources involved contribute to the input; therefore, output is the measuring item for achieving organizational goals. So, you only need to set up the organizational goal; then, the evaluative standard will be built up,

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following which, you can select the input and output items (Kao et al., 2003).

In referring to local and foreign research studies, recognizing the input and output items of influential factors in measuring the maintenance efficiency of airplane logistics, this study selects six input and three output items as follows:

- Input items: the amount of maintenance personnel, total working hours of maintenance, number of defects in working on the aircraft and its accessories, amount of training class, total hours of technological training.
- Output items: the amount of aircraft and accessories fixed and coming out of the factory, the maintenance quality of aircraft and accessories, and the total number of qualified trainees.

2.4 Choice of DEA model

This study adopts the model of "input oriented scale of fixed and variable returns"; the main reason is that the amount of repaired aircraft and accessories coming out of factory is controlled by the fixed number in advance, and the maintenance quality of aircraft and accessories must be kept to a certain standard condition of technological document regulation, in order to minimize the involved maintenance personnel, cost, training hours and the resources consumed in relation to the number of defects in the repairing process, while sustaining the same amount of output, quality and training level for the purpose of saving cost.

3. Case study

3.1 Using application software DEA

The software used is the 4.2 version Frontier Analyst software by Banxiz Software, and the usage mainly involves three major aspects: data input, model selection and results analysis. After executing the DEA, it is time to engage in performance evaluation and strategy development. Then, the evaluative results are analyzed and explained, in determining the aspects of insufficient actions and to provide useful information to build up an effective feedback system. This is followed by carrying out corrective action to improve the technological training and determine the direction of improvement.

3.2 Analysis of training vs. effect of maintenance

Training input items refer to the numbers of defects in the factory, the number of maintenance class and training hours. On the other hand, the maintenance effect refers to output item: the value of defects in fixed aircraft coming out of the factory and the number of qualified trainees. In general, the bigger the value, the better the training's effect on maintenance results. Th X-axis in Fig. 1 is the efficiency value of training in regard to the maintenance effect, while the Y-axis is the number of DMUs. The figure shows that in the 12 DMUs, there are only nine effective units; the other three DMUs' effeciency still need much improvement.

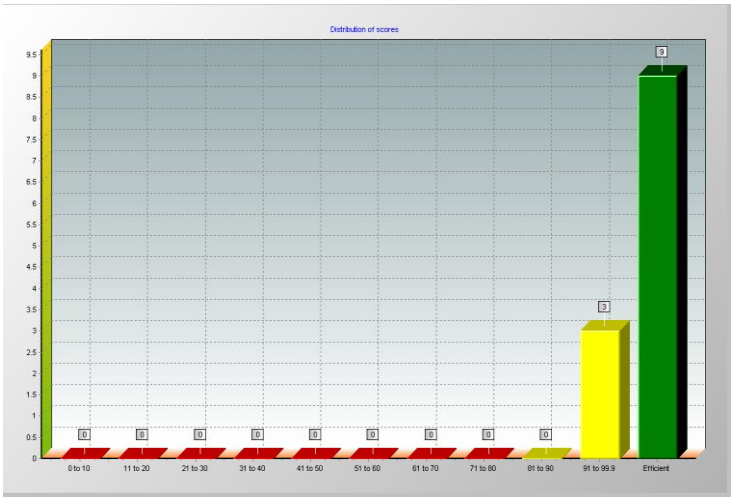

Fig. 1 Efficiency value statistics of DMU's training effect related to maintenance

In terms of the input oriented perspective, a manager can make reference to Table 1 to understand which training DMU needs to be adjusted (such as training period and timing of on-job-training), the intensity of the courses, so as to coordinate work progress and balance the load of manpower, because the arranged practical training classes might lead to problems, such as the delayed progress of important jobs. These steps can make the DMU's application of training efficiency for maintenance results achieve the efficiency standard on the leading edge of the envelope.

Table 1 Efficiency value of DMU's training effect on maintenance results and reference frequency (BBC model)

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Unit	Score	RTS	Refs
A1	**92.78**	**-1**	**0**
A2	100.00	-1	2
A3	100.00	-1	1
A4	100.00	-1	1
A5	100.00	-1	1
A6	100.00	1	2
B1	**96.36**	**1**	**0**
B2	**94.03**	**1**	**0**
B3	100.00	-1	3
B4	100.00	1	3
B5	100.00	0	2
B6	100.00	1	1

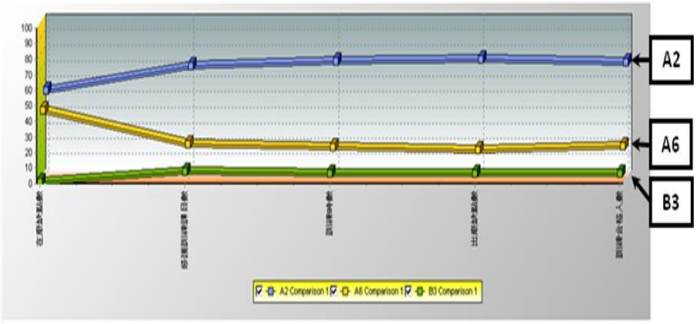

Fig. 2 Training effect on maintenance results (DMU A1's efficient value is 92.78%).

The DMU A1 value chosen in Fig. 2 with the lowest efficiency can be used as the basis to explore the training effect. The X-axis is the input/output item, while the Y-axis is the contribution value of efficiency of the training results. The figure shows different output items: the number of defects in the fixed aircraft coming out of the factory and the number of qualified trainees, while the input items include the number of defects in the factory, the number of maintenance training classes and the contribution value of the relative efficiency of the training hours. All three units: A2, A6 and B3, in Fig. 2 are the goals of efficient improvement for inefficient unit A1, but among the three target units, there are different contributions to input/ output items' efficiency. From Fig. 2, it can be seen that the A2 unit has the top efficiency contribution for all the input/output items as the target unit for efficiency improvement. Therefore, comparing the efficiency value of DMU A1 with the most efficient unit of A2 gets the lowest efficient value 92.78% of maintenance results, as shown in Fig. 3.

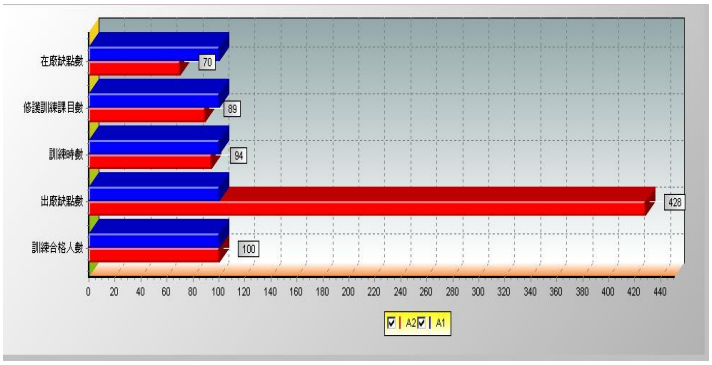

Fig. 3 Comparison of training effect on maintenance results (DMU A1-efficient value is 92.78%)

The X-axis of Fig. 3 is the comparative value of relative efficiency, while the Y-axis is the input/output items. From Table 1 and Fig. 2, it is seen that the A2 unit is the best efficient DMU unit among the DMUs. In Fig. 3, comparing inefficient DMU A1 with the most efficient DMU A2 means that A2's number of defects in factory is 30% less than that of A1, the number of A2's implementing maintenance training classes is 11% less than that of A1, and A2's consummation of training hours is 6% less than that of A1; but in the aspect of output, A2's number of defective products leaving the factory is 328% more than that of A1. In terms of the input oriented perspective, if A1 wants to reach the same efficiency level in training, it needs to make references to A2 for potential improvements, as shown in Fig. 4.

Fig. 4 Potential improvement value of training effect on maintenance results (DMU A1's efficiency value is 92.78%)

The X-axis of Fig. 4 is the comparative increase/decrease ratio value of relative efficiency, while the Y-axis is the input/output items. The figure shows that A1's number of qualified trainees is quite similar to that of A2, but in comparison with A2, A1 (which

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is the lowest training efficient DMU) must increase maintenance training courses by 8% and training hours by 7%.

In terms of improving the efficiency of maintenance results, A1's maintenance result is the lowest. In view of the quality and quantity of training, A1's efficiency is lower than those of the other DMUs.

4. Conclusion and Suggestion

Management should focus on properly adjusting the hours of maintenance and training, so as to achieve reasonable work and reduce unnecessary consumption of working hours; when confronting resignations, retirements and restructuring, the training units should lay out schedule in advance to prevent the training from yielding its window period. Units of various levels should reduce the times of inspection and supervision, so as to cut down the DMU's stress in the preparation of, and the influence on, personnel training.

Management can also adopt the DEA performance evaluation method to find the direction for improving training efficiency for the organization. At the same time, it can also effectively resolve the upstream technological problems and downstream quality problems. Therefore, in order to prevent such inefficiency fluctuations, management should focus on the trainees' understanding ability and different expertise needs, followed by coordination with the organizational factors, such as phases of the task, work burden and on-the-job-training, to make training more effective in improving maintenance quality.

In practical management, supervising and encouraging better future results is far more important than reviewing the past. In general, the DEA model always uses the data on past happenings into calculating and analyzing. If the uncertain data can be added to the scheme of calculation, the organization or enterprise should use performance evaluation in developing future strategies; it would enable the enterprise to obtain indicators of more concrete competitive advantage.

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